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Carbon Monoxide Packaging of Meats May Mask Spoilage & Compromise Public Health Safety

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Abstract: Carbon monoxide is a colorless, odorless, poisonous gas often found in industrial and vehicular emissions. The recent approval of carbon monoxide by the US FDA as a "generally regarded as safe" or GRAS food fixative to be used in fresh meat has created some level of public health concern and controversy among scientists, lawmakers, Governments and all stakeholders in the food industry. Several countries have since banned the use of carbon monoxide packaging. The health effects of consuming food tainted with carbon monoxide are unknown and highly questionable. Carbon monoxide is a poisonous, toxic gas and its use in food packaging systems should be cautioned and reviewed in light of pending findings of ongoing short and long term studies.

Key words: carbon monoxide packaging, public health safety

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The Problem

The US FDA in 2002 and in 2004 approved the use of carbon monoxide as a color fixative in case-ready meats, that falls under the notification process known as a Generally Regarded As Safe substance or GRAS (1-3). GRAS notification process means that the FDA conducts no independent safety analyses, but relies only on notifier's claims. In addition, no warning statement is required on labels to indicate to the consumer and the general public that meat products is stored under carbon monoxide modified atmosphere packaging (4).

However, the approval of carbon monoxide as a color fixative in fresh meat products may be in contravention with Section 173.350 of the FDA Regulations. Section 173.350 of the FDA Regulations prohibits the use of carbon monoxide in fresh meat products.

Additionally, the USDA and FSIS Regulations prohibit the use of ingredients in fresh meat that conceal damage or inferiority (5).

The approval of carbon monoxide as a "color fixative" or as a "color additive" needs clarification and urgent review. What is a color fixative? A color fixative is defined by the Codex Alimentarius as an agent that stabilizes, retains or intensifies color (6). What is a color additive? The Codex Alimentarius defines a color additive as an agent that adds or restores color in food (6). Carbon monoxide may be both a fixative and additive, since freshly cut meat looks purple red, but with the addition of carbon monoxide the meat becomes irreversibly pink in color. The requirements for approval of and properties of a color additive are clearly defined by the Federal, Food, Drugs and Cosmetic Act and require pre-market approval, establishing safety standard for use, range of uses, health effects and other toxicological effects.

According to the US Food, Drugs and Cosmetic Act, a food additive is defined as "any substance for use or which results or may reasonably be expected to result, directly or indirectly, in its becoming a component or otherwise affecting the characteristics of any food…"

The widespread use of carbon monoxide in fresh meat products has the potential for consumer deception and

possible health risks (3-4). This approval of carbon monoxide sparked widespread public health concerns (7) and many countries have since banned the use of carbon monoxide in meat packaging.

What is carbon monoxide?

Carbon monoxide is a colorless, odorless and toxic gas. It is produced by the incomplete combustion of fossil fuels, industrial and biological processes.

How does carbon monoxide interact with myoglobin?

Carbon monoxide combines with myoglogin in meat to form carboxymyoglobin, a stable cherry-red compound. It is believed that this stable red colour may conceal spoilage and may put consumers at risk, because the stable red color is stable beyond the microbial shelf-life of the product, it can easily create consumer deception.

This consumer deception can create health risks for consumers whether intentionally or unintentionally (4, 7). Meats in carbon monoxide packaging may appear and smell fresh even when they are contaminated with harmful bacteria such as Clostridium botulinum, Salmonella, Campylobacter, and E-coli 0157:H7 (4,7).

What are the health effects of carbon monoxide?

Carbon monoxide is poisonous and very dangerous toxic gas because it can readily bind with oxygen carrying molecules called hemoglobin in the blood to form carboxyhemoglobin. Once carboxyhemoglobin is formed in the blood, oxygen is unable to bind to hemoglobin and therefore hemoglobin is no longer available for the transport oxygen to cells, tissues, and vital organs such as the heart and brain. Thus cells, tissues and vital organs may become hypoxic and undergo irreversible anatomical, biochemical and physiological changes leading to death and morbidity (8-12).

The health risk associated with carboxyhemoglobin is dependent on the concentration of carbon monoxide and the duration of exposure. In addition, the time it takes for the concentration of carboxyhemoglobin in the blood to decrease to half its value is approximately 5 hours. This means that carbon monoxide is not immediately cleared in the body and maybe or become toxic to body cells and tissues. It may form adducts with other molecules at a molecular level which may lead to disruption of molecular and cellular functions leading to apoptosis or programmed cell death (8-12).

What symptoms are associated with carbon monoxide poisoning?

Low concentrations of carbon monoxide

- Headaches.
- Dizziness.
- Temporary loss of muscle coordination.
- Memory damage.
- Vision damage.

High concentrations of carbon monoxide

- Impaired ability of blood to carry oxygen.
- Convulsions.
- Coma.
- Respiratory failure.
- Lowered birth weight.
- Nervous system damage in offspring.

Long-term low or high exposure of carbon monoxide

- Heart disease.
- Central nervous system damage.
- Death.

What symptoms are associated with a given concentration of carboxyhemoglobin?

- 10 % carboxyhemoglobin-no observable symptoms.
- 15% carboxyhemoglobin-mild headache.
- 25 % carboxyhemoglobin-nausea and serious headache.
- 30 % carboxyhemoglobin-intensification of symptoms.
- 45 % carboxyhemoglobin-unconsciousness.
- 50 % carboxyhemoglobin-death.

What symptoms are associated with a given concentration of carbon monoxide over a specified period?

- 35 p.p.m carbon monoxide for 8 h-maximum limit allowed by OSHA (13).
- 200 p.p.m carbon monoxide for 2-3 h-mild headache, fatigue, nausea, dizziness.
- 400 p.p.m carbon monoxide for 1-2 h-serious headache, life threatening after 3 h.
- 800 p.p.m carbon monoxide for 45 min-dizziness, nausea, convulsions. Unconscious within 2 h death within 2-3 h.
- 1600 p.p.m carbon monoxide for 20 min-headache, dizziness, nausea. Death within 1 h.
- 3200 p.p.m carbon monoxide for 5-10 min-headache, dizziness, nausea. Death within 1 h.
- 6400 p.p.m carbon monoxide for 1-2 min-headache, dizzinness, nausea. Death within 25-30 min.
- 12,800 p.p.m carbon monoxide for 1-3 min-Death.

Why is carbon monoxide used in meat packaging?

Carbon monoxide is generally believed to be an inert gas and its use together with other gases such as carbon dioxide and nitrogen serve to create a modified atmosphere that limit or reduce the growth of aerobic microorganisms. This modified atmosphere would then serve to extend the shelf life of packaged meat as much as 35 days possibly by limiting the growth of microorganisms (5).

What percentage of carbon monoxide is used in meat packaging?

Meats packaged using modified atmosphere packaging (MAP) normally utilizes a carbon monoxide concentration not exceeding 0.4 %; other components of this MAP system

are carbon dioxide (30 %) and nitrogen (69.6 %). Some of the troubling questions surrounding the level of carbon monoxide used in meat packaging include, but not limited to:

- What percentage of carbon monoxide used in MAP is absorbed by the packaged meat?
- Do meats of different animal origins (pork, chicken, beef, lamb, duck, deer, etc.) absorb carbon monoxide differently? If so, why?
- Do different cuts of meat absorb carbon monoxide differently? And if so, why?
- How does cooking (types: frying, baking, roasting, grilling, boiling, barbequing) affect the percentage of carbon monoxide present in cooked meat?
- What percentage of carbon monoxide is transferred to the consumer?
- What are the possible health effects (short and long term) of consuming carbon monoxide?
- What are the possible molecular and cellular interactions that may result as a consequence of consuming carbon monoxide packaged meat products?

These questions have not been answered conclusively, to date, and there is much need for rigorous, empirical investigative studies that will provide these answers in a timely manner.

Which countries ban the use of carbon monoxide in their meat packaging systems?

The carbon monoxide packaging system is used for packaging fresh cuts of muscle meat and ground meat to maintain wholesomeness, provide greater flexibility in distribution and possibly storage, and to reduce shrinkage of meat (2), but, at what health risks to the consumer.

Some countries worldwide have totally eliminated the use of carbon monoxide in their food packages (4).

- European Union.
- Japan.
- Canada.
- Singapore.

Conclusion

Carbon monoxide is a poisonous, toxic gas. Its use in modified atmosphere packaging is questionable and may pose serious health risks in susceptible high risk individuals such as young children, pregnant women, the elderly and immunocompromised patients who are diabetic, and are afflicted with kidney and liver problems. There are no completed reported long term studies on the effects of carbon monoxide consumption in foods on human health and these studies are urgently needed. The approval of carbon monoxide as a color fixative may be unjustifiably classified as a GRAS. Carbon monoxide may also be classified as a color additive. If this is the case then more rigorous approval would be required by regulatory agencies, in particular the US FDA and other similar agencies, worldwide. Since the use of carbon monoxide in meat packaging can stabilize the red pigment far beyond the microbial shelf-life, this fact may be used in a deceptive manner whether intentionally or unintentionally and may expose consumers, susceptible individuals and the general population to undue health risks.

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